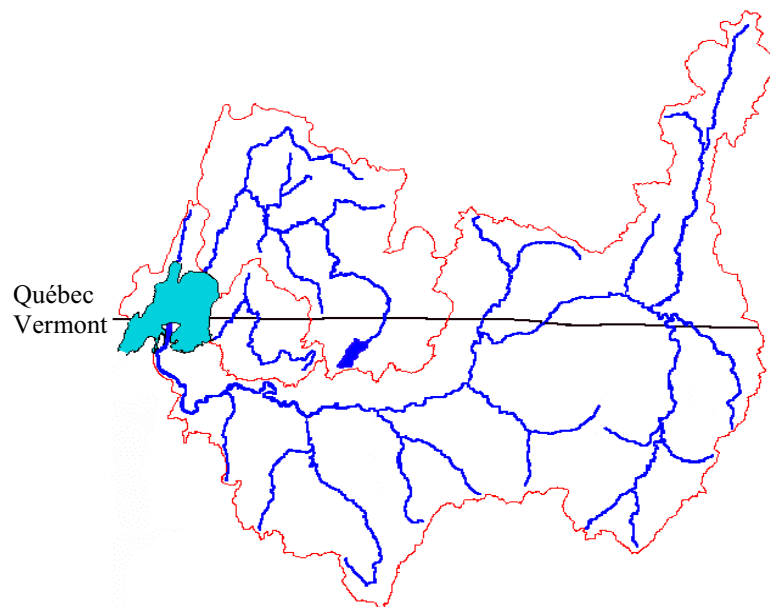


**A DIVISION OF RESPONSIBILITY BETWEEN QUÉBEC AND VERMONT
FOR THE
REDUCTION OF PHOSPHORUS LOADS TO MISSISQUOI BAY**

The Report of the Missisquoi Bay Phosphorus Reduction Task Force
to the
Lake Champlain Steering Committee



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ACRONYMS AND ABBREVIATIONS

BMP	best management practice
LCMC	Lake Champlain Management Conference
mgd	millions of gallons per day
mg/l	milligrams per liter
mt/yr	metric ton (1,000 kilograms) per year
NYSDEC	New York State Department of Environmental Conservation
MENV QC	Quebec Ministry of the Environment
TMDL	Total Maximum Daily Load
VT DEC	Vermont Department of Environmental Conservation
WWTP	wastewater treatment plant

1. INTRODUCTION

Phosphorus pollution has been identified as one of the highest priority issues facing Lake Champlain (Lake Champlain Management Conference 1996). The Province of Québec and the States of Vermont and New York have been working together formally for over a decade to reduce the amount of phosphorus entering the lake from all sources throughout the Lake Champlain basin. Missisquoi Bay, which crosses the Québec-Vermont border at the northern end of the lake, receives the largest phosphorus load of any section of the lake. The phosphorus concentrations in the bay are also consistently among the highest measured in the lake. The source of this phosphorus is primarily runoff from the land, also known as nonpoint source. Much of the land is used for agriculture, especially in the lake valley and along rivers and streams. Like the bay itself, the land in the Missisquoi Bay basin lies in both Québec and Vermont, and each of the three major streams cross the border more than once before reaching the bay, making it difficult to determine how much of the nonpoint source phosphorus originates in each jurisdiction.

This report presents the work of the Missisquoi Bay Phosphorus Reduction Task Force, a cooperative effort between Québec and Vermont to develop a division of responsibility for the reduction of phosphorus loads to the lake from the Missisquoi Bay basin. The report describes the previous agreements, technical studies, and new analyses that form the basis for a draft Québec-Vermont agreement. It also provides an overview of the coordinated phosphorus management programs that will lead toward meeting the established load reduction targets.

2. BACKGROUND

2.1 *Memorandum of Understanding*

In 1988, the Governors of Vermont and New York and the Premier Ministre du Québec signed a *Memorandum of Understanding on Environmental Cooperation on the Management of Lake Champlain* (renewed in 1992 and 1996) (Vermont, New York, and Québec 1996). The memorandum created the Lake Champlain Steering Committee to serve as a forum for exchange of information and discussion of programs and policies affecting Lake Champlain. When the memorandum was renewed in 1996, the three jurisdictions committed to participate in cooperative actions guided by the recommendations in the lakewide management plan, *Opportunities for Action*, which had recently been completed by the Lake Champlain Management Conference (1996).

2.2 *Water Quality Agreement*

In 1992, the Steering Committee established a Lake Champlain Phosphorus Management Task Force to develop recommendations for a consistent approach between New York, Québec, and Vermont for phosphorus management in Lake Champlain. This group recommended in-lake total phosphorus concentration criteria for 13 lake segments as management goals for all three jurisdictions, including a criterion of 0.025 milligrams per liter (mg/l) for Missisquoi Bay. The

in-lake phosphorus criteria were endorsed in a New York-Québec-Vermont Water Quality Agreement signed in 1993 (New York, Québec, Vermont 1993). These criteria have also been formally adopted as part of the Vermont Water Quality Standards.

2.3 Lake Champlain Diagnostic-Feasibility Study

In 1997, Vermont and New York completed the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State DEC 1997). The study included extensive field data collection on the lake and its tributaries during 1990-1992. It produced a lakewide phosphorus loading budget, mass balance model, and load reduction strategy designed to attain the in-lake phosphorus criterion in each lake segment. Results from the study indicated that the total phosphorus loading to Missisquoi Bay during the 1991 base year was 167.3 metric tons per year (mt/yr), including both point and nonpoint sources from the three major tributary watersheds. The study also found that the mean total phosphorus concentration in Missisquoi Bay was 0.035 mg/l, which substantially exceeded the water quality criterion of 0.025 mg/l. The study did not, however, distinguish the nonpoint source loads between Vermont and Québec.

2.4 Opportunities for Action

Shortly before the start of the Diagnostic Feasibility Study, the US Congress passed the Lake Champlain Special Designation Act of 1990. The Act established the Lake Champlain Management Conference, a bi-state committee with representatives from diverse groups in the basin, and charged it with preparing a comprehensive environmental management plan for the lake. The plan, *Opportunities for Action* (LCMC 1996), was completed in 1996 and included a phosphorus reduction agreement negotiated between the States of Vermont and New York and the US Environmental Protection Agency. It established allowable phosphorus loads from 13 sub-basins, or lake segment watersheds, divided by state, based on the results of the Lake Champlain Diagnostic-Feasibility Study. The states retained the flexibility under the agreement to modify point and nonpoint source loading allowances within each state, provided that no load reduction responsibility was shifted to the other state.

2.5 Missisquoi Bay Phosphorus Reduction Task Force

For the Missisquoi Bay lake segment, *Opportunities for Action* specified a phosphorus loading target of 109.7 mt/yr, based on the Lake Champlain Diagnostic-Feasibility Study. This target load represents a 57.6 mt/yr reduction from the 1991 measured load to Missisquoi Bay of 167.3 mt/yr. The plan also indicated that Vermont would seek an agreement with the Province of Québec on sharing responsibility for phosphorus reduction in Missisquoi Bay. To that end, Québec and Vermont established the Missisquoi Bay Phosphorus Reduction Task Force through the *Agreement on the Formation of a Missisquoi Bay Phosphorus Reduction Task Force* (Appendix A). The Task Force was charged to review the earlier agreements on load reduction targets for Missisquoi Bay, assess phosphorus loading to the bay by source and location, review the policies and programs available to implement phosphorus controls in the Missisquoi Bay

basin, and propose a fair and practical division of responsibility between Vermont and Québec for achieving the target load reductions.

Since *Opportunities for Action* was completed, there has been interest in shortening the 20-year timeframe for reducing phosphorus loads. In 1999, the Lake Champlain Steering Committee formed a Phosphorus Reduction Team to assess the feasibility of accelerating phosphorus reduction efforts, including a preliminary assessment of progress toward achieving the loading targets in each segment of the lake. The findings of the Missisquoi Bay Task Force were developed in the context of this related report (Lake Champlain Basin Program 2000) and the broader lakewide phosphorus management program.

3. REVIEW OF PHOSPHORUS LOADING TO MISSISQUOI BAY

3.1 Point Sources - Vermont

There are seven municipal and one industrial wastewater treatment facilities that discharge phosphorus to surface waters in the Vermont portion of the Missisquoi Bay watershed (Table 1). All eight facilities have discharge permits from the State of Vermont that specify flow limits in millions of gallons per day (mgd), and three of these facilities have permit limits for phosphorus concentration or loading.

Table 1. Phosphorus Concentrations and Loads From Vermont Wastewater Treatment Facilities in the Missisquoi Bay Watershed

Facility	Permitted			1998 Measured Mean		
	Flow (mgd)	Conc. (mg/l)	Load (mt/yr)	Flow (mgd)	Conc. (mg/l)	Load (mt/yr)
Enosburg Falls	0.450	0.80	0.497	0.296	0.54	0.211
Newport Center	0.042	*	*	0.022	-	-
North Troy	0.110	*	*	0.067	-	-
Richford	0.380	*	*	0.281	-	-
Rock Tenn	3.500	0.80	3.478	0.301	1.17	0.464
Sheldon Springs	0.054	*	*	0.036	-	-
Swanton	0.900	1.00	1.242	0.486	0.64	0.574
Troy/Jay	0.200	*	*	0.034	-	-

* Of these facilities, only Enosburg Falls, Rock Tenn, and Swanton have phosphorus limits in their discharge permits.

- No effluent phosphorus concentration data or load estimate available.

mgd = million gallons per day

Source: VT DEC

Enosburg Falls and Rock Tenn are required to attain a state statutory phosphorus concentration limit of 0.8 mg/l. Swanton is exempt from the 0.8 mg/l limit because it is an aerated lagoon facility, but it is required to meet a 1.0 mg/l concentration limit under a previous statute. All of the other facilities in the watershed are exempt from statutory phosphorus limits, either because they are small (less than 0.200 mgd permitted flow) or use an aerated lagoon treatment process.

Only those facilities with phosphorus limits in their discharge permits have been required to monitor for effluent phosphorus concentration. Consequently, there are no operational data for some of the facilities listed in Table 1 to assess actual phosphorus discharges during 1998 or other recent years. However, phosphorus monitoring requirements are being added for all facilities as their discharge permits are renewed, so more complete point source data will be available in the near future. All the facilities in the watershed achieved their applicable flow and phosphorus loading limits on an annual average basis during 1998, although the Rock Tenn facility is not yet meeting the 0.8 mg/l concentration limit.

3.2 Point Sources - Québec

There are 8 municipal wastewater discharges in the Québec portion of the Missisquoi Bay watershed (Table 2). Discharges from Stanbridge Station and Les Aliments Carrières (Snyder) are pre-treated and directed to the facility in Bedford. The town of St.-Georges-de-Clarenceville has been connected to the Venise-en-Québec treatment plant, which discharges to the Richelieu River. In 1998, three of the discharges were from aerated lagoon treatment facilities with target effluent concentrations of 1 mg/L. Similar aerated lagoon facilities at Sutton and Stukely-Sud were completed in 1999, a Saint-Armand facility will be completed in 2000, and facilities for the remaining two discharges are expected to be completed within 2-3 years. Monitoring data for the Bedford plant indicates that the effluent phosphorus concentrations are generally below the 1 mg/l target (about 0.7mg/l). Effluent concentrations for the other facilities are estimates. For those discharges without treatment facilities in place in 1998, the phosphorus loads are calculated assuming a contribution of 0.002 kg phosphorus/person/day.

Table 2. Phosphorus Concentrations and Loads From Québec Point Source Discharges in the Missisquoi Bay Watershed

Facility	1998 Mean			
	Flow (m ³ /d)	Flow (mgd)	Conc. (mg/l)	Load (mt/yr)
Abercorn	130	0.040	*	0.188
Bedford	3800	1.004	1.00	1.387
Eastman	243	0.064	1.00	0.089
Notre-Dame-de-Stanbridge	420	0.111	*	0.339
Potton	244	0.064	1.00	0.089
Stukely-Sud	67	0.018	*	0.179
Sutton	1350	0.357	*	1.825
St.-Armand	176	0.046	*	0.292

* No concentration data are available. Loads have been estimated assuming a contribution of 0.002 kg phosphorus/person/day.
 mgd = million gallons per day
 Source: MENV QC

3.3 Nonpoint Sources – Vermont and Québec

Estimates of the total nonpoint source phosphorus load to Missisquoi Bay were developed for the 1991 reference year as part of the Lake Champlain Diagnostic-Feasibility Study (Table 5). However, data from the study did not allow separation of nonpoint source loading from Québec and Vermont because the loads were determined by sampling near the river mouths where inputs from the entire watershed are integrated.

The Lake Champlain Basin Program funded a study to estimate the nonpoint source phosphorus loads separately from Québec and Vermont. The study used recent land use information (ca. 1993) for the entire Lake Champlain basin and other data to develop a model for estimating phosphorus export from different land uses in individual sub-watersheds. Special emphasis in the study was placed on modeling phosphorus export from the Missisquoi Bay watershed to support the information needs of the Task Force. The Task Force participated in the development of the request-for-proposals, approved the contractor selection, provided data and technical oversight during the project, and reviewed the project final report, *Estimation of Lake Champlain Basinwide Nonpoint Source Phosphorus Export* (Hegman et al. 1999). More details about the nonpoint source phosphorus export methods used in this report are provided in Appendix B.

Hegman et al. (1999) presented several alternative models for estimating phosphorus export from individual watersheds, based on land use information, hydrologic data, and other variables. The models were calibrated to 1991 reference year phosphorus loading data for 30 Lake Champlain tributaries, obtained from the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State DEC 1997). The Task Force determined that the most appropriate model for use in the Missisquoi Bay watershed was the “loading function” model with variables that included the area of land use in forest, agriculture, and urban categories, as well as the density of farm animals on agricultural land.

The distribution of land use in the Missisquoi Bay watershed is shown in Table 3, based on Hegman et al. (1999). The Vermont portion of the watershed represents 58% of the total area, with the remaining 42% located in Québec. Agricultural land uses occupy 21% of the watershed in Vermont and 30% of the area in Québec.

Table 3. Distribution of Land Use in the Missisquoi Bay Watershed (ca. 1993)

	Land Use Areas								Total Area (km ²)
	Vermont				Québec				
	Area (km ²)	For (%)	Ag (%)	Urb (%)	Area (km ²)	For (%)	Ag (%)	Urb (%)	
Missisquoi	1,594	66.0	19.3	4.7	646	80.5	10.5	4.1	2,240
Rock	92	37.4	39.2	5.4	55	44.4	45.0	5.4	147
Pike	102	47.2	30.9	4.6	565	42.3	48.0	4.6	667
Direct	2	46.2	16.2	19.7	49	20.3	58.0	12.4	51
Total	1,790	63.0	21.0	4.7	1,315	60.3	29.8	4.7	3,105

Land Use/Land Cover: For=Forested, Ag=Agricultural, Urb=Urban

Data from Hegman et al. 1999

Nonpoint source phosphorus loading estimates developed by Hegman et al. (1999) for each land use category in Québec and Vermont are shown in Table 4. Vermont contributed 62% of the total nonpoint source phosphorus load to Missisquoi Bay, and Québec contributed 38% of the total. Agricultural sources accounted for 81% of the Vermont nonpoint load and 77% of the Québec nonpoint load.

Table 4. Distribution of Nonpoint Source Phosphorus Loading Between Major Land Uses in the Missisquoi Bay Watershed

	Phosphorus Loading (metric tons/year)								Total
	Vermont				Québec				
	For	Ag	Urb	Total	For	Ag	Urb	Total	
Missisquoi	2.9	53.9	12.4	69.2 (75.9%)	1.5	1.2	4.9	7.7 (13.7%)	76.9 (52.1%)
Rock	0.1	9.3	0.8	10.1 (11.1%)	0.1	6.5	0.5	7.1 (12.6%)	17.2 (11.7%)
Pike	0.1	10.8	0.8	11.8 (12.9%)	0.7	33.9	4.4	39.0 (69.2%)	50.8 (34.4%)
Direct	0.0	0.0	0.1	0.1 ($<0.1\%$)	0.0	1.5	1.0	2.5 (4.4%)	2.6 (1.8%)
Total	3.1 (3.4%)	74.1 (81.2%)	14.1 (15.5%)	91.2 (100%)	2.3 (4.1%)	43.2 (76.7%)	10.7 (19%)	56.3 (100%)	147.5 (VT = 62%) (QC = 38%)

Land Use/Land Cover (Circa 1993): For=Forested, Ag=Agricultural, Urb=Urban (As presented in Hegman et al. 1999)

4. DIVISION OF RESPONSIBILITY BETWEEN QUÉBEC AND VERMONT FOR PHOSPHORUS REDUCTION IN MISSISQUOI BAY

The main purpose of the Missisquoi Bay Phosphorus Reduction Task Force was to propose a fair and practical division of responsibility between Vermont and Québec for achieving the target load reductions for Missisquoi Bay. The Task Force believed that the basis for the division should be as simple and clear as possible.

4.1 Review of the Overall Target Phosphorus Load for Missisquoi Bay

The Task Force began by reviewing the overall target load developed for Missisquoi Bay as part of the Lake Champlain Diagnostic-Feasibility Study to determine whether it was an appropriate basis for establishing separate loading targets for Québec and Vermont. The Task Force

examined an issue that was raised in the Diagnostic-Feasibility Study report, internal phosphorus cycling. Internal phosphorus cycling processes, such as sediment-water phosphorus exchange, can affect the rate at which in-lake phosphorus concentrations respond to reductions in phosphorus loads to the lake. The Diagnostic-Feasibility report acknowledges that internal phosphorus cycling within Missisquoi Bay and some other highly eutrophic areas of the lake were not directly modeled in the analysis that was used to set the target phosphorus loads to achieve the in-lake phosphorus concentration criteria. If these internal processes were not sufficiently accounted for by the model, the concentration of phosphorus in Missisquoi Bay may not meet the 0.025 mg/l concentration criterion for some time after the target loads have been reached.

The Diagnostic-Feasibility Study report called for additional research into internal phosphorus cycling in Lake Champlain. The Lake Champlain Basin Program sponsored a two-part follow-up study investigating these issues that was completed in 1999 (HydroQual Inc. 1999; Cornwell and Owens 1999). Although the study provided additional information about the role of internal phosphorus cycling in the lake, the findings were inconclusive for Missisquoi Bay. Data collected from sediment core studies indicated that sediment-water phosphorus exchange was greater in the highly eutrophic areas of the lake like Missisquoi Bay. These data were incorporated into a new model of phosphorus behavior in the lake. In general, the modeling results supported earlier work (Martin, et al. 1994) indicating that there may be significant delays between reductions in phosphorus loading and changes in average phosphorus concentrations in lake. However, the study concluded that additional data collection and model refinement will be needed to more accurately predict the internal phosphorus dynamics in Missisquoi Bay and similar areas of the lake.

The Task Force agreed that, until these internal phosphorus cycling mechanisms are better understood in Missisquoi Bay, the Lake Champlain Diagnostic-Feasibility Study data and modeling analysis results provide the best starting point for a division of responsibility for phosphorus loads to Missisquoi Bay. Namely, the total phosphorus loading estimate of 167.3 mt/yr for the 1991 base year is the best available reference point on which to base a load reduction modeling analysis for Missisquoi Bay, and the target load of 109.7 mt/yr derived from this modeling analysis is the appropriate load for achieving the 0.025 mg/l phosphorus concentration criterion for Missisquoi Bay. The loads and required reductions are summarized in Table 5 below.

4.2 Division of Responsibility

The Task Force determined that Québec and Vermont should divide the required 57.6 mt/yr loading reduction in proportion to their respective loading contributions during the 1991 reference year, as shown in Table 5. The total 1991 load to the bay of 167.3 mt/yr estimated by the Diagnostic-Feasibility Study included 15.4 mt/yr from point sources in Québec and Vermont, and 151.9 mt/yr from nonpoint sources (Table 5). The 151.9 mt/yr nonpoint source load was divided into Vermont and Québec portions, based on the results of the study by Hegman et al. (1999) which showed that the relative contributions were 62% from Vermont and 38% from

Québec (Tables 4). When both the point and nonpoint loads were considered, Vermont contributed 60% of the 1991 total load and Québec contributed 40% (Table 6).

Table 5. Phosphorus Loading to Missisquoi Bay (mt/yr)

Load	Point	Nonpoint	Total
Measured 1991 Loads			
Missisquoi R.	9.5	75.1	84.6
Pike R.	5.9	44.4	50.3
Rock R.	0.0	28.9	28.9
Direct Drainage	0.0	3.5	3.5
Total	15.4	151.9	167.3
Target Load			109.7
Load Reduction Needed			57.6

Loads measured by the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State DEC 1997)

Phosphorus loading target is from *Opportunities for Action* (LCMC 1996)

Table 6. Proposed Basis for a Division Of Responsibility Between Québec and Vermont for Phosphorus Load Reduction to Missisquoi Bay

Load	Vermont	Québec	Total
Measured 1991 Loads			
Point	6.9 ^a	8.5 ^a	15.4 ^a
Nonpoint	94.2 ^b	57.7 ^b	151.9 ^a
Total	101.1	66.2	167.3 ^a
Percent of Total	60%	40%	100%
Target Load	65.8	43.9	109.7 ^a
Load Reduction Needed	34.6	23.0	57.6 ^a

^a Value obtained from the Lake Champlain Diagnostic-Feasibility Study (Vermont DEC and New York State DEC 1997)

^b Division between Vermont (62%) and Québec (38%) portions of the total nonpoint source load was based on Hegman et al. (1999).

The 60/40% division between Vermont and Québec was used by the Task Force as the basis for dividing responsibility for load reductions, as shown in Table 6. The Task Force determined that Vermont should accept a target load of 65.8 mt/yr (60% of 109.7 mt/yr), and Québec should accept a target load of 43.9 mt/yr (40% of 109.7 mt/yr). Expressed as load reduction requirements relative to the 1991 base year load, the Vermont responsibility should be a reduction of 34.6 mt/yr (60% of 57.6 mt/yr) and the Québec responsibility should be a reduction of 23.0 mt/yr (40% of 57.6 mt/yr).

Note that the 1991 point and nonpoint source loading values indicated in Table 6 do not represent future load allocation decisions within Vermont or Québec. In Vermont, decisions about phosphorus load allocations to point and nonpoint sources in the Lake Champlain Basin will be made through the Total Maximum Daily Load (TMDL) process. The Task Force recommends that Québec and Vermont remain free to choose the combination of point and nonpoint source phosphorus control measures that each jurisdiction determines will be the most cost-effective means to attain their respective overall target loads given in Table 6. Draft language for a Missisquoi Bay Phosphorus Reduction Agreement between Québec and Vermont is presented in Appendix C (English and French versions).

5. POLICIES AND PROGRAMS ADDRESSING PHOSPHORUS MANAGEMENT

This section summarizes programs and policies in Québec and Vermont related to reducing phosphorus loads to surface waters. Because land use in the non-forested areas of the Missisquoi Bay watershed is predominantly agricultural, the focus here is primarily on agricultural phosphorus management programs. Other programs, policies and legislation in both jurisdictions also address planning and stormwater management from urban and developed areas.

5.1 Addressing Point Sources - Québec

The Québec government, in partnership with local municipalities, has supported extending wastewater treatment through its Clean-Up Wastewater program. Treatment facilities have been constructed in several towns and several others have been connected to the new or existing facilities. Additional facilities are currently being built or planned for all remaining point source discharges. In the Missisquoi Bay watershed, all current and planned wastewater treatment facilities use an aerated lagoon treatment process with a target effluent concentration of 1.0 mg/l.

Federal regulations on phosphorus concentration in laundry detergents have been in effect in Canada since 1973. The *Regulations Respecting the Concentration of Phosphorus in Laundry Detergents* (SOR/89-501) specify that the concentration of phosphorus in any laundry detergent used in Canada shall not exceed 5 percent by weight expressed as phosphorus pentoxide, or 2.2 percent by weight expressed as elemental phosphorus.

5.2 Addressing Point Sources - Vermont

A state law in Vermont (10 V.S.A. §1266a) restricts all discharges in the Lake Champlain and Lake Memphremagog drainage basins larger than 0.2 mgd in permitted flow (exempting municipal aerated lagoon facilities) to an effluent phosphorus limit of 0.8 mg/l on a monthly average basis. This requirement is effective for municipalities only to the extent that 100% state grant funds are provided for the construction cost of phosphorus removal facilities.

In the Missisquoi Bay watershed, this statutory requirement applies only to the Enosburg Falls and Rock Tenn discharges. The Enosburg Falls facility was upgraded in 1996 and is now achieving the 0.8 mg/l limit (see Table 2). The Rock Tenn industrial facility is under a State order to achieve the 0.8 mg/l limit by the end of 2000.

Vermont has had a statutory phosphorus detergent ban in effect since 1978 (10 V.S.A. §1381-1384). This law prohibits the sale of household cleansing products containing more than a trace amount of phosphorus, with some exceptions. It was estimated that this law reduced phosphorus loading to Lake Champlain from Vermont point sources by 40%.

In addition to the above statutory requirements, Vermont Water Quality Standards (Section 3-01-3.c.) require that “there shall be no significant increase over currently permitted loadings” to Lake Champlain and Lake Memphremagog. As a result, any new or expanding wastewater treatment facilities in the Missisquoi Bay watershed will be required to maintain annual phosphorus loadings at their existing permitted levels or lower.

5.3 Addressing Nonpoint Sources - Québec

The Ministère de l'Environnement du Québec (MENV QC) participates on the Interministerial Regional Missisquoi Bay Joint Action Committee, along with representatives from other provincial ministries (Agriculture, Municipal, Tourism, Wildlife, etc.). Since 1997, the committee has been developing an action plan for cleaning up pollution in Missisquoi Bay. It also supports the recently created *Missisquoi Bay Basin Corporation* that will bring together stakeholders from the Québec portion of the Missisquoi Bay watershed to determine how to address issues including reduction of phosphorus loads to the bay. The regional action plan will focus the efforts of current programs from several ministries and agricultural groups. The main objectives are:

- Reduction of phosphorus, nitrogen, and pesticide loading in a specific sub-watershed of the Pike River
- Construction of efficient manure storage facilities wherever needed by 2003, as required by regulation
- Implementation of nutrient management plans by 2004, as required by regulation
- Promotion of proper farming practices (soil and water conservation, buffers strips)
- Increased application of other regulatory requirements concerning the reduction of pollution from agricultural sources
- Participation of many partners, local groups and the farmers' union.

The regional plan will incorporate the on-going Québec Agroenvironmental Investment Assistance Program (since 1988), the Soil and Water Conservation Program, and the Clean-Up Wastewater Program, which provide funding and technical support to encourage sustainable agriculture practices and enhanced wastewater treatment. Agricultural projects include nutrient and manure management, agroenvironmental advisory services, erosion control, infrastructure improvement for manure storage, air pollution abatement, and manure treatment or volume reduction. The regional action plan is also based on a regulation in place since 1981 that bans manure spreading on frozen ground or snow cover. This regulation was modified in 1997 to require farmers to develop nutrient management plans with phosphorus limits. The regional plan will also pursue other projects to reduce point and nonpoint phosphorus loads from municipalities in the Missisquoi Bay Watershed through the *Missisquoi Bay Basin Corporation*.

5.4 Addressing Nonpoint Sources - Vermont

Agricultural nonpoint source pollution control in Vermont involves the combined efforts and resources of state and federal government programs and cooperating landowners. Vermont's Accepted Agricultural Practices Rules (effective June, 1995) define agricultural land use practices that reduce the amount of agricultural pollutants entering Vermont's waters. Compliance with Accepted Agricultural Practices (AAPs) is mandatory, and state and federal cost-share assistance is available to farmers to support compliance. Examples of AAPs include:

- Banning winter manure spreading.
- Applying nutrients at agronomic rates.
- Constructing and managing manure storage structures.
- Quickly incorporating manure into soil on certain cropland that is subject to annual overflow of adjacent streams or rivers.
- Cultivating soil in a manner to reduce soil loss.
- Creating perennial vegetative buffer strips between row cropland and streambanks to filter pollutants and reduce streambank erosion.

Vermont's Best Management Practices (BMPs) are site specific, on-farm remedies that address water quality problems. They are generally voluntary, but can be required by the state. The state provides financial assistance to Vermont farmers for voluntary construction of on-farm improvements, such as manure storage structures, which are designed to reduce agricultural nonpoint source discharges, including phosphorus, into Vermont waters. This cost-share program works in conjunction with federal financial assistance programs.

Farmers in Vermont are required to apply for and receive a permit from the state to construct a new facility, expand an existing facility, or operate a farm which exceeds the animal unit limitations set forth in state statute. This permitting process is designed to review all aspects of the large farming operation, including the farm's nutrient management plan, and address areas of concern to ensure the farming operation is in compliance with state and federal regulations. Currently there are three permitted large farm operations in the Missisquoi Bay Basin.

5.5 Additional Efforts

The Task Force believes that it should be made clear that attainment of the target loads for the Missisquoi Bay watershed given in Table 6 will most likely require efforts that go beyond existing phosphorus management programs in both Vermont and Quebec. The Lake Champlain Basin Program (2000) evaluation of progress toward phosphorus reduction goals indicated that full implementation of all currently planned agricultural Best Management Practices (BMPs) and all planned wastewater treatment facility upgrades in the Missisquoi Bay watershed will not produce enough phosphorus reductions to meet the target loads in either Vermont or Quebec. Additional efforts may need to include more stringent phosphorus removal requirements at wastewater treatment facilities and more extensive agricultural best management practices and stronger controls for developed land.

6. MONITORING OF PROGRESS

Currently, progress by Québec and Vermont toward attainment of the target phosphorus loads to Missisquoi Bay is monitored by estimating point and nonpoint source loads to the bay from each jurisdiction. Changes in point source loads are easier to track, especially as routine phosphorus monitoring of wastewater discharges is expanded to more facilities. Reductions in nonpoint source phosphorus loads, however, are much more difficult to quantify and track.

To estimate changes in nonpoint source loads, both Québec and Vermont are developing inventories of agricultural practices and BMP implementation. Reduction “credits” for each practice are subtracted from the 1991 base year loads measured during the Diagnostic-Feasibility Study (VTDEC and NYSDEC 1997). A preliminary assessment of the reduction credits is being developed for the entire Lake Champlain basin by the Phosphorus Reduction Team as part of its investigation into shortening the timeframe for reducing phosphorus loads to the lake, but the results are not yet available. Both the Missisquoi Bay Phosphorus Reduction Task Force and the Phosphorus Reduction Team have noted that load estimates based on this crediting system are increasingly uncertain as the time since the loads were measured grows.

The Québec Ministry of the Environment, the Vermont Department of Environmental Conservation, and the US Geological Survey (USGS) operate a number of river flow gages and water quality sampling stations in the Missisquoi Bay watershed. The existing river flow gage and sampling station network is shown in Figure 1. It would be possible with a relatively modest expansion of the existing network to measure phosphorus loading separately from Québec and Vermont by monitoring loads at the border crossings. The major needs are for additional flow gauging stations located near the border on the Pike River, the Rock River, and possibly the Sutton River. It may also be necessary to increase the frequency of monitoring at the Québec sampling stations to obtain more samples under high-flow conditions, as needed for more accurate phosphorus loading estimates.

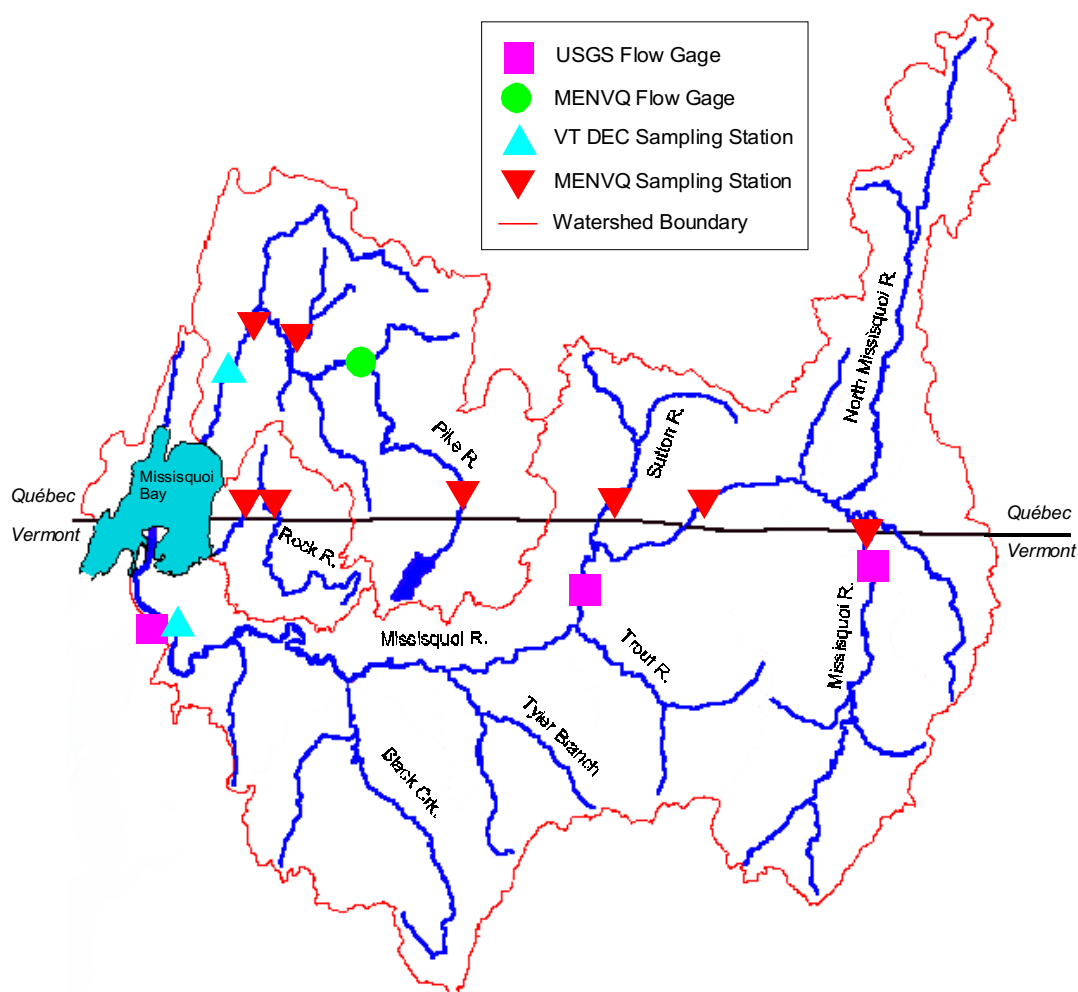


Figure 1. Existing flow gage and sampling station network in the Missisquoi Bay watershed.

The Task Force recommends the following steps to improve the monitoring that is needed to track progress in phosphorus reductions:

- Vermont and Québec should take steps to ensure that all wastewater treatment facilities in the Missisquoi Bay watershed are monitored regularly for effluent flow and total phosphorus concentration.
- Databases on the implementation of agricultural and other nonpoint source BMPs in the Missisquoi Bay watershed should be enhanced, including the development of consistent nonpoint source phosphorus reduction accounting procedures for Québec and Vermont.
- The river flow and phosphorus monitoring network in the Missisquoi Bay watershed should be expanded to permit the direct measurement of phosphorus loads from Vermont and Québec, including sites where the Missisquoi, Pike, and Rock Rivers cross the international border.

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APPENDIX A: AGREEMENT ON THE FORMATION OF A MISSISQUOI BAY PHOSPHORUS REDUCTION TASK FORCE

Presented to the Lake Champlain Steering Committee by

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Secretary, Vermont Agency of Natural Resources

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Directrice régionale de la Montérégie du ministère de l'Environnement et de la Faune

March 25, 1997

The State of Vermont and the Province of Québec agree that phosphorus reduction in Missisquoi Bay should be a high priority for the management of water quality in Lake Champlain. In 1993, the Province of Québec and the States of Vermont and New York signed a Lake Champlain Water Quality Agreement endorsing a phosphorus criterion of 0.025 mg/l for Missisquoi Bay. In 1996, the Lake Champlain Management Conference approved a plan calling for a reduction in the phosphorus loading to Missisquoi Bay from Vermont and Québec down to a target level of 109.7 metric tons per year.

In order to implement the phosphorus reductions necessary in Missisquoi Bay, the State of Vermont and the Province of Québec have agreed to the formation of a Missisquoi Bay Phosphorus Reduction Task Force. The Task Force will be composed of staff from the Vermont Agency of Natural Resources, the Québec Ministry of the Environment and Wildlife, and other agencies as appropriate. The Task Force will accomplish the following items and report back to the Lake Champlain Steering Committee by March 1999.

1. Review and reach technical concurrence on the phosphorus loading data and modeling analyses used to establish load reduction targets for Missisquoi Bay. Propose and conduct additional research if necessary.
2. Assess the magnitude of phosphorus loading to Missisquoi Bay from Vermont and Québec, and from each source category and sub-watershed. Develop additional land use data and watershed phosphorus modeling analyses as necessary to support this assessment.
3. Review the policies and programs in Vermont and Québec that are in effect or available to implement point and nonpoint source phosphorus reductions in the watershed of Missisquoi Bay.
4. Propose a fair and practical division of responsibility between Vermont and Québec for achieving the target load reductions for Missisquoi Bay. Identify specific point and nonpoint source management actions and schedules within each jurisdiction to achieve the target loads.

APPENDIX B: TECHNICAL REPORT DETAILS - ESTIMATION OF LAKE CHAMPLAIN BASINWIDE NONPOINT SOURCE PHOSPHORUS EXPORT

Completed in 1999 by Hegman, Wang, and Borer, this Lake Champlain Basin Program-funded study provided the basis for the Missisquoi Bay Task Force's division of phosphorus loads from nonpoint sources in the Missisquoi Bay watershed. Additional information on the methods and findings of this study are provided below.

Background

Implementing the phosphorus reduction goals in the Lake Champlain basin required a geographical assessment of nonpoint source loads. This study updated and refined the original basin-wide nonpoint source phosphorus assessment done in 1994 by Budd and Meals (LCBP Tech. Report 6A/B). Digital land cover data from 1992 was used with animal unit density information to update phosphorus loading coefficients. Recent research and the availability of geographic information system (GIS) technology made it possible to do a more flexible and sophisticated analysis than the previous study, which relied on older land use information and coefficients from the literature that were developed elsewhere. To support the work of the Missisquoi Bay Phosphorus Reduction Task Force, part of the study focused on the Missisquoi Bay watershed.

Methods

Using regression techniques, the authors developed phosphorus loading coefficients for three major land uses (agriculture, urban and forest) based on the 1991-92 phosphorus loading data collected as part of the Diagnostic-Feasibility Study and the 1993 land use information developed by the Lake Champlain Basin Program. Data on the number of animals (animal units) were also included in the analysis to account for differences in animal density in different areas of the basin, especially in the Missisquoi Bay watershed.

Two different kinds of coefficients were developed: export coefficients and loading coefficients. Export coefficients are average values for the mass of phosphorus exported per area, per year (units of kg/ha/yr). In this simplified approach, only land use data are required to predict phosphorus loads from any part of the basin. Loading coefficients are a function of pollutant concentration and runoff volume (units of mg/L). With the loading model, fluctuations in annual rainfall amounts, and the resulting change in phosphorus loads, can be accounted for. If precipitation data are available, the loading method provides a better estimate of phosphorus loading to the lake for any given year,. After developing the export and loading coefficients, a GIS was used to apply the coefficients to individual cells classified as forested, agricultural, or urban. Load for these cells were then summarized to predict phosphorus loads from sub-watersheds in the basin.

Conclusions

For the entire Lake Champlain basin, the land was 67% forested, 17% agricultural, and 5.5% urban. Agricultural land use contributed 56% of nonpoint source phosphorus to the lake, while urban land uses contributed 37% of the phosphorus load, even though it constitutes only a small portion of the total land. The Missisquoi Bay watershed was determined to be the largest contributor of nonpoint point source phosphorus to the lake, compared to all other lake segments. About 26% of the watershed is used for agriculture, yet 79% of the nonpoint source phosphorus originates from agricultural areas. The watershed also appears to deliver larger per unit area phosphorus load compared to other agricultural areas in the basin. Although other factors may play a role, this excess phosphorus load was linked to the greater density of agricultural animals in the watershed. Lastly, the study concluded that Vermont contributes about 62% of the total nonpoint source phosphorus load to Missisquoi Bay, and Québec contributes 38% of the total.

APPENDIX C: DRAFT QUÉBEC-VERMONT AGREEMENT ON PHOSPHORUS REDUCTION IN MISSISQUOI BAY

Background

The Missisquoi Bay watershed is shared between the Province of Québec and the State of Vermont. In 1993, Québec, and Vermont, along with New York, signed a Lake Champlain Water Quality Agreement that established in-lake total phosphorus concentration criteria for each segment of Lake Champlain, including a 0.025 mg/L (milligrams per liter) criterion for Missisquoi Bay. In 1996, the three jurisdictions endorsed *Opportunities for Action*, the basinwide management plan for Lake Champlain. The plan established target phosphorus loads for each segment of the lake that will result in meeting the corresponding in-lake concentration criteria, including a 109.7 mt/yr (metric tons per year) target for total phosphorus loading to Missisquoi Bay from Québec and Vermont combined.

Québec and Vermont have since been working through the Missisquoi Bay Phosphorus Reduction Task Force to develop a fair and practical division of responsibility for attaining the load reductions needed to meet the target. The Task Force reviewed the existing loading targets and in-lake criterion for Missisquoi Bay, initiated a study of nonpoint source phosphorus loads from Missisquoi Bay subwatersheds, and reviewed phosphorus management programs and policies in each jurisdiction. These activities are summarized in the Task Force report, which provides the detailed justification for the agreement presented below.

Draft Agreement on Phosphorus Reduction in Missisquoi Bay

Québec and Vermont agree to the following terms:

1. The in-lake criterion for total phosphorus in Missisquoi Bay (0.025 mg/L), established in the 1993 New York-Québec-Vermont Water Quality Agreement, continues to be an appropriate goal for phosphorus management in the Missisquoi Bay watershed.
2. The total target phosphorus load for the Missisquoi Bay watershed (109.7 mt/yr) and the timeframe for reaching this target load (20 years), both established in *Opportunities for Action*, continue to be an appropriate overall loading limit and schedule for attaining the necessary reductions.
3. The relative contributions of phosphorus from Québec and Vermont to Missisquoi Bay that were measured during the 1991 reference year provide the basis for a division of responsibility for reducing loads to the maximum allowable target load of 109.7 mt/yr. Based on the report of the Missisquoi Bay Phosphorus Reduction Task Force, the phosphorus load to Missisquoi Bay during 1991 is apportioned at 60% from Vermont and 40% from Québec. Accordingly, the target load for Vermont will be 65.8 mt/yr, and the target load for Québec will be 43.9 mt/yr.

4. Québec and Vermont hereby commit to achieving their respective target loads for the Missisquoi Bay watershed in a manner consistent with the schedule and conditions for Lake Champlain phosphorus reduction established in *Opportunities for Action*. Québec and Vermont are free to choose the appropriate point and nonpoint source controls that will result in reducing phosphorus loads to the allowable levels. Specific actions and targeted areas will be identified by each jurisdiction in the context of the ongoing phosphorus reduction efforts being coordinated through the Lake Champlain Basin Program, including the five-year evaluation of progress scheduled for completion in 2001.
5. To facilitate the tracking and reporting of progress toward attaining the target loads, Québec and Vermont will enhance phosphorus monitoring of Missisquoi Bay tributaries and wastewater effluent from treatment facilities in the watershed. The two jurisdictions will also work toward developing consistent methods for tracking nonpoint source best management practices implemented in the watershed.
6. If new scientific information warrants, the in-lake phosphorus criterion or target load for the Missisquoi Bay watershed may be changed by mutual agreement between Québec and Vermont.

Approved on this _____ day of _____, 2000.

Ministre, ministère de l'Environnement du Québec

Secretary, Vermont Agency of Natural Resource

ANNEXE C : PROPOSITION D'ENTENTE QUÉBEC-VERMONT SUR LA RÉDUCTION DU PHOSPHORE DANS LA BAIE MISSISQUOI

Exposé de la situation

Le bassin versant de la baie Missisquoi couvre à la fois les territoires du Québec et de l'État du Vermont. En 1993, le Québec, le Vermont et l'État de New York signaient une entente sur la qualité de l'eau du Lac Champlain établissant les critères de concentration du phosphore total pour chaque section du lac, dont un critère de 0,025 mg/L (milligramme par litre) pour la baie Missisquoi. En 1996, les autorités compétentes de ces trois états entérinaient le plan de gestion global du lac Champlain « *Opportunities for Action* ». Ce plan fixait des charges cibles de phosphore pour chaque segment du lac de manière à faire respecter les critères de concentration. Pour la baie Missisquoi la charge globale commune du Québec et du Vermont a été établie à 109,7 tonnes métriques par an.

Depuis, le Québec et le Vermont, par l'entremise du Groupe de travail Vermont-Québec sur la réduction du phosphore, s'affairent à la répartition pratique et équitable des responsabilités en vue d'atteindre les réductions de charges nécessaires au respect de la cible. Jusqu'ici, le Groupe de travail a analysé les charges et les critères en cours pour la baie, a entrepris une étude des sources diffuses de phosphore dans le sous-bassin de la baie et a examiné les programmes et politiques de gestion du phosphore en vigueur dans les deux états. Ces actions sont résumées dans le rapport du Groupe de travail qui justifie de façon détaillée l'entente formulée ci-dessous.

Proposition d'entente sur la réduction du phosphore dans la baie Missisquoi

Le Québec et le Vermont conviennent de ce qui suit :

1. Le critère pour le phosphore total dans la baie Missisquoi (0,025 mg/L), établi dans l'Entente New York-Québec-Vermont sur la qualité de l'eau de 1993, constitue toujours un objectif pertinent pour la gestion du phosphore dans le bassin versant de la baie Missisquoi.
2. La charge cible totale pour le phosphore dans le bassin versant de la baie Missisquoi (109,7 tm/an) et l'échéancier pour l'atteindre (20 ans), tels qu'ils ont été établis dans le plan de gestion « *Opportunities for Action* », continuent d'être pertinents pour l'atteinte des réductions recherchées.
3. Les contributions relatives de phosphore par le Québec et le Vermont à la baie Missisquoi, mesurées durant l'année de référence 1991, servent de base à la répartition des responsabilités devant permettre de réduire les charges au niveau de la charge maximale acceptable de 109,7 tm/an. Selon le rapport du Groupe de travail Vermont-Québec sur la réduction du phosphore, en 1991 le Vermont contribuait 60 % de la charge de phosphore dans la baie Missisquoi et le Québec, 40 %. En conséquence, la charge cible du Vermont sera de 65,8 tm/an et la charge cible du Québec, de 43,9 tm/an.

4. Par la présente, le Québec et le Vermont s'engagent à atteindre leurs charges limites respectives pour le bassin versant de la baie Missisquoi conformément à l'échéance et aux conditions de réduction du phosphore établis pour le lac Champlain dans le plan de gestion « *Opportunities for Action* ». Le choix des sources ponctuelles ou diffuses à maîtriser pour amener les charges de phosphore à la limite acceptable est laissé à la discrétion du Québec et du Vermont. Les autorités compétentes verront à identifier les actions prévues et les régions ciblées dans le contexte des efforts de réduction en cours et coordonnées par le Lake Champlain Basin Program, dont le bilan quinquennal prévu en 2001.
5. Afin de faciliter le suivi dans l'atteinte des charges cibles et la production de rapports d'étape, le Québec et le Vermont verront à accroître leurs mesures de contrôle du phosphore présent dans les tributaires de la baie Missisquoi et du phosphore rejeté par les stations d'épuration dans le bassin versant. Ils veront également à mettre au point des méthodes compatibles de suivi d'implantation des pratiques culturelles de protection de l'environnement dans le bassin versant.
6. Le Québec et le Vermont pourront, par entente mutuelle, modifier le critère de concentration ou la charge cible du phosphore pour la baie Missisquoi si de nouvelles données scientifiques le justifient.

Approuvé en ce _____ jour de _____ 2000.

Ministre, ministère de l'Environnement du Québec

Secretary, Vermont Agency of Natural Resources